REMARKS

Reconsideration and re-examination are hereby requested.

With regard to Examiner's objection to Page 4, paragraph 0014, such appears to the Applicant as a complete sentence: i.e., " FIG. 1 is a graph showing the relationship between NOx conversion efficiency and the multiplier factor f2 as a function of temperature for a green catalyst:"

Approval of changes to FIG., 2 as indicated in red is hereby requested. The change removes the numerical designation "29" at the decision block to compare T_EXO and T_EXO_THRES as requested by the Examiner.

Applicant wishes to discuss two points referred to by the Examiner in the "Response to Arguments" section.

1. LIGHT-OFF

The term "light-off" refers to a specific **event**. It is not a temperature range, but rather a ***specific event*** that typically occurs **once per key-on session**. The method and system according to the invention inject the hydrocarbon into the engine exhaust in accordance with detection of a light-off **event.** The **light-off *event*** can be detected because when there is a hydrocarbon-O2 reaction (i.e., the exotherm is generated by the reaction of HC with O2, not with NOx), such reaction is an exothermic reaction and thus heat is generated and given off. The generation of such heat may be detected by measuring the difference in temperature across the catalyst. The peak in NOx conversion efficiency temperature changes with age. However, **because the peak in NOx conversion efficiency *temperature* occurs at substantially *the same temperature as light off event*,** a determination of light-off by the system and method enables adjustment in the hydrocarbon injection level for maximum NOx reduction efficiency.

Thus, LIGHT-OFF refers to an EVENT not a temperature RANGE, as described by the Examiner.

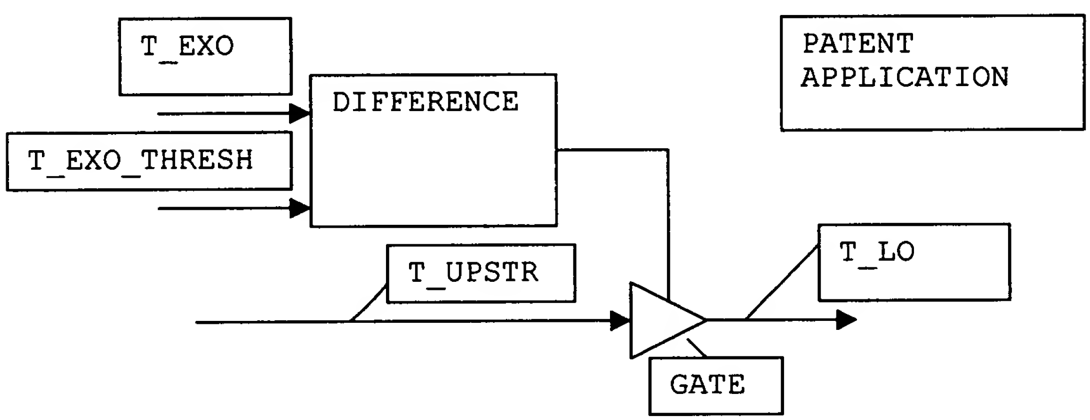
2. The phrase "DETECTING A TEMPERATURE OF AN OUTPUT OF THE CATALYST IN RESPONSE TO THE DETECTED EXOTHERMIC REACTION "

With the present invention, the difference between T_EXO and T_EXO_THRESH is used to detect a light-off EVENT. When such light-off EVENT is detected such detection serves as a gating signal to gate the temperature at the output of the catalytic converter, i.e., the

temperature T_UPSTR, through gate 30 to provide the light-off temperature, T_LO. ***The temperature T2 of Hirota et al in NOT the output temperature of the catalyst BUT RATHER THE UPPER LIMIT OF A TEMPERATURE RANGE. See col. 5, lines 26-28:***

> "Then, at step 106, a lower temperature limit T1 AND AN **UPPER** TEMPERATURE **LIMIT T2 OF A TEMPERATURE RANGE** where the lean NOx catalyst 6 can operate with a high NOx purification rate are calculated so as to correspond to the calculated running distance S using the map of FIG. 2" (emphasis added)

This EVENT detection process is illustrated below:



Note that the event occurs only when T_EXO exceeds T_EXO_THRESH.

Further, note that when the EVENT occurs, the temperature at the output of the catalytic converter is gated through gate 30, i.e., the output temperature of the catalytic converter is detected. More particularly, T2 is a temperature that is looked up, whereas our light-off temperature is measured (i.e.., an output of the catalyst in response to the detected exothermic reaction).

Still further, it is respectfully pointed out that the Examiner's interpretation of Hirota's delta Ti, as understood appears incorrect. The Examiner uses his interpretation to reject claims 4-11, reference being made to page 4 of the Examiner's reply. The term Ti (ΔTi) is not a predetermined temperature threshold, but an exotherm, see col 9 lines23-26. wrong! exotherm = Δt

Applicant hereby reiterates the position stated in the last response and provides such response below for the convenience of the Examiner:

Referring to FIG. 2, as described in the patent application, if the computed exotherm T_exo exceeds a threshold level T_exo_thres, the light-off temperature, T_lo, (i.e., the temperature produced by the upstr sensor 20 when the computed exotherm T_exo exceeds the threshold level T_exo_thres) is detected and such light-off signal T_lo is passed through a gate 30 to a subtractor 32. Gate 30 is an enabled gate to close temporarily when its enabling input exhibits a rising edge from negative to positive; otherwise it is open. This light-off temperature, T_lo which passes through gate 30 when such gate is temporarily closed, is compared with the light-off temperature expected for the catalyst 24 when such catalyst 24 was green; i.e., an expected light-off temperature T_lo_exp_green. This expected light-off temperature, T_lo_exp_green, is a function of total exhaust flow. Thus T_lo_exp_green (i.e., T_CAT_OPTIMUM) as a function of total exhaust flow is stored in a look-up table 35. The table 35 is fed the actual total exhaust flow by a sensor disposed in the engine intake air system . The output of the look-up table 35 is thus the light -off temperature expected for a green catalyst, i.e., T_lo_exp_green. This temperature T_lo_exp_green, along with the actual light-off temperature T_lo of the catalyst 24 (which was passed through gate 30) are fed to the subtractor 32. The subtractor 32 computes T_lo_diff = T_lo-T_lo_exp_green (i.e., the difference between

the actual light-off temperature of catalyst 24 and the light-off temperature expected for a green catalyst). Thus, T_lo_diff is, as described above, a function of the aging of the catalyst 24 and particularly the effect of aging of the catalyst 24 on the optimum conversion temperature T_CAT_OPTIMUM (FIG. 1)

This difference T_lo_diff is used to compute f2 for multiplication with fl produced by the look-up table 27 and thereby produce the correct control signal on line 19 for the HC injector 18. More particularly, the function f2 for a green catalyst must be shifted as described above in connection with FIG. 2 so that f2 produced by a calculator 39 is equal to f2 where f2 is the curve 17 of FIG. 3 shifted in temperature T_lo_diff, here 20 degrees C to produce curve 19 in FIG. 3.

To put it another way, T_lo_diff = T_lo - T_lo_exp_green (i.e., where T_lo is the current light-off temperature of the catalyst 24 and T_lo_exp_green is the light-off temperature of the catalyst prior to its aging). The function multiplied by fl in multiplier 29 is f2 for a green catalyst shifted in temperature by T_lo_diff. Thus, the calculator 39 produces f2 for multiplication with fl in multiplier 29 which is a function of temperature in accordance with the curve 19 in FIG. 3 if, for example, T_lo_diff = 20 degrees C.

The calculator 39 includes an integration to make T_lo_diff depend not only on the last recorded light-off (i.e., T_lo), but the average off the last few light-off events. Thus, the calculator computes the temperature for peak NOx conversion efficiency in accordance with T_lo(k) =T_lo(k+1)+ki*T_lo_diff, where ki is a calibration gain less than one. Thus, f2 = f2 for a green catalyst shifted in temperature by T_lo_diff =T_lo(k+1)-T_lo_exp_green.

Considering now U.S. Patent No. 5,201,802 (Hirota et al.), as described beginning at column 9, lines 10 through line 55:

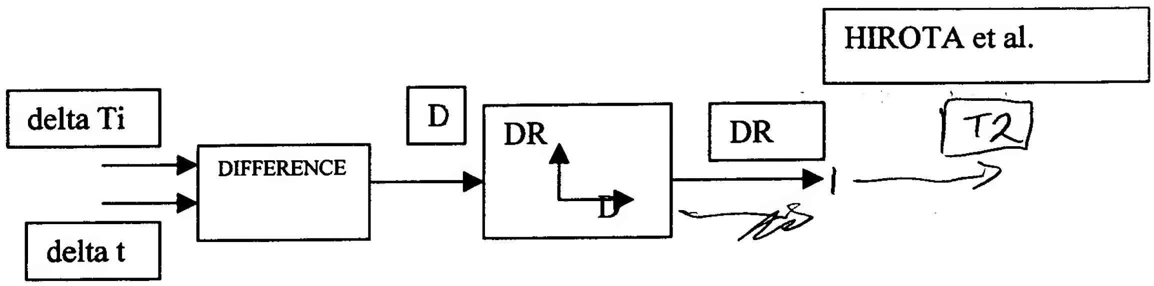
> FIG. 14 illustrates a routine for determining degradation of the lean NOx catalyst 6. This routine is entered at intervals of predetermined periods of time, for example, at intervals of fifty milliseconds. At step 602, a determination is made as to whether or not the current engine operating condition is in a catalyst degradation determining condition, for example, in a warmed-up and usual running condition. If the current condition is not in the catalyst degradation determining condition, the routine returns. If the current condition is in the catalyst degradation determining condition, the routine proceeds to step 604, where the current engine load Q/N and the current engine speed NE are entered.

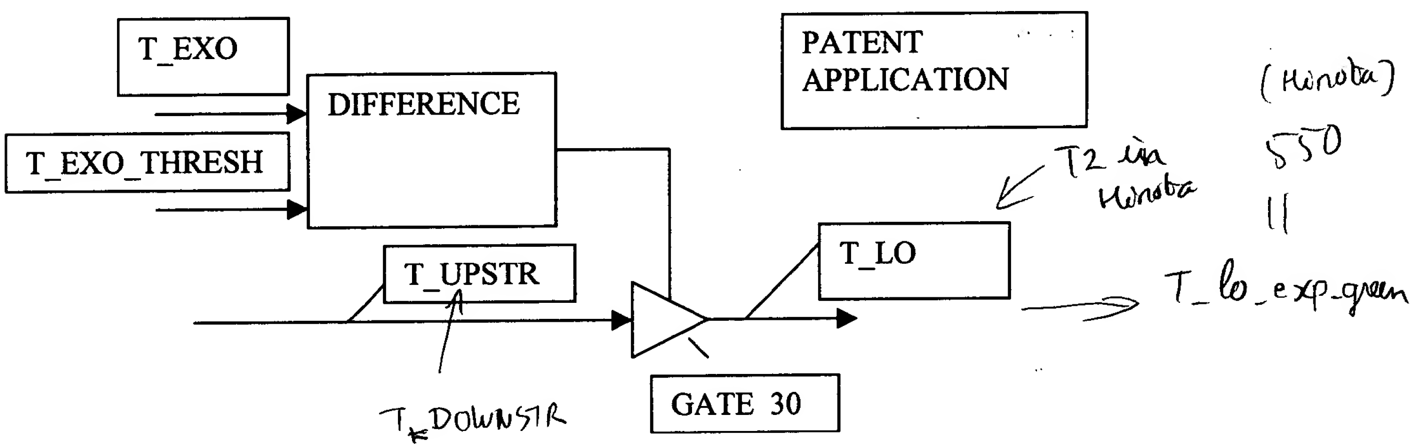
Then, at step 606, a predetermined reference temperature difference (delta Ti) between the inlet gas and the outlet gas of the lean NOx catalyst 6, which corresponds to the engine load and engine speed conditions, is read from a map of FIG. 15.

Then, at step 608, the difference between the current inlet gas temperature t1 (output of the temperature sensor 24) and the current outlet gas temperature t2 (output of the temperature sensor 20) of the lean NOx catalyst 6 is calculated using the equation delta t=t2-t1. Then, at step 610, a catalyst degradation function D is calculated as a difference between the current temperature difference delta t and the reference temperature difference delta Ti using the equation D=delta Ti-delta t. Then, at step 612, a catalyst degradation extent DR is calculated using a map of DR versus D map of FIG. 16. In this instance, the steps 604 through 612 and FIG. 16 constitute the means for determining degradation of the lean NOx catalyst 6 in the third embodiment.

Then, at step 614, a lower limit T1 and an upper limit T2 of an object temperature range for the catalyst 6 are calculated based on the catalyst degradation extent DR using a map of object temperature range versus catalyst degradation extent of FIG. 17. In FIG. 17, there is a relationship between the temperatures T1 and T2 and the degradation extent DR such that the larger the value DR is, the higher the temperatures T1 and T2 are. Then, at step 616, the lower limit of the object temperature range TC is replaced by the calculated T1 and the upper limit of the range TH is replaced by T2. The control of catalyst temperature is executed according to the routine of FIG. 4 which was discussed. Then, the routine proceeds to step 618, where an object HC concentration H1 is calculated using the map of H1 versus DR of FIG. 18. In FIG. 18, there is a relationship between the object HC concentration H1 and the degradation extent DR such that the larger the DR is, the higher the HC concentration H1 is. At step 620, the object HC concentration HT is replaced by the calculated H1. The control of the HC amount is executed using the routine of FIG. 5 which was discussed. In this instance, the steps 618 and 620 and FIG. 18 constitute the means for increasing the amount of hydrocarbons supplied to the lean NOx catalyst 6 in the third embodiment. Further, the steps 614 and 616 and FIG. 17 constitute the means for increasing the catalyst temperature when the catalyst 6 has been degraded in the third embodiment.

A comparison between the description above in the Hirota et al. patent and the system described by the Applicant above is summarized in the sketch below:





Thus, in Hirota et al. the difference between delta Ti and delta t provides D and D is used as an input to a lookup table to find DR. Hirota et al, does not determine an exothermic condition temperature at an output of the catalyst when the temperature difference is determined to exceed the threshold. With the present invention, on the other hand, the difference between T_EXO and T_EXO_THRESH is used to detect a light-off condition and when such light-off condition is detected such detection serves as a gating signal to gate the temperature an the light-off temperature, T_lo, (i.e., the temperature produced by the upstr sensor 20 when the computed exotherm T_exo exceeds the threshold level T_exo_thres) through the gate 30 to a subtractor 32. Thus, the gate 30 is an enabled gate to close temporarily when its enabling input exhibits a rising edge from negative to positive; otherwise it is open. This light-off temperature, T_lo which passes through gate 30 when such gate is temporarily closed, is compared with the light-off temperature expected for the

downstream ?

catalyst 24 when such catalyst 24 was green; i.e., an expected light-off temperature T_lo_exp_green. ← T2 ~~of Hirota~~ 550, in Hirota

Referring now to the claims, claim 1 includes injecting the hydrocarbon into the engine in accordance with detection of a light-off event. Such process is not described in King et al., Kilbe et al, not Hirota et al.

Claim 4 includes "(b) detecting a temperature of an output of the catalyst in response to the detected exothermic reaction". Such process is not described in King et al., Kilbe et al, not Hirota et al.

Claim 5 includes:

> (c) determining an <u>exothermic condition temperature at an output of the catalyst when the temperature difference is determined to exceed the threshold</u>;
> (d) comparing <u>the determined exothermic condition temperature</u> with an <u>exothermic condition temperature expected from the catalyst at a time prior to the determined exothermic condition temperature</u>; and
> (e) modifying the injected hydrocarbon in accordance with said comparison. (emphasis added)

Thus, referring to FIG. 2. the determined exothermic condition temperature (T_UPSTR at light-off (i.e., T_LO) is compared with T_LO_EXP_GREEN. Hirota et al, does not determine an <u>exothermic condition temperature at an output of the catalyst when the temperature difference is determined to exceed the threshold</u>; comparing <u>the determined exothermic condition temperature</u> with an <u>exothermic condition temperature expected from the catalyst at a time prior to the determined exothermic condition temperature</u>; and modify the injected hydrocarbon in accordance with said comparison, as claimed in set forth in claim 5.

Claim 5 has been amended to correct an error to thereby provide proper antecedent basis for "comparison".

Claim 6 includes:

(b) comparing the temperature difference with a predetermined temperature threshold;

(c) determining an exothermic condition temperature at an output of the catalyst when the temperature difference is determined to exceed the threshold. (emphasis added).

Claim 7 has been amended to point out that processor being programmed to:

compare a difference in the common parameter detected by the pair of sensors with a predetermined threshold;

determine an exothermic condition at an output of the catalyst when the difference in the common parameter is determined to exceed the threshold;

compare the determined exothermic condition with an exothermic condition expected from the catalyst at a time prior to the determined exothermic condition; and

modify the injected hydrocarbon in accordance with said last-mentioned comparison.

Such is not described in the cited references for reasons set forth above.

Claim 8 has been amended to correct an improper claim dependency and to provide proper antecedent support for "sensor".

Claim 9 points out that the control signal is provided by steps comprising:

comparing a difference in the common parameter detected by the pair of sensors with a predetermined threshold;

determining an exothermic condition at an output of the catalyst when the difference in the common parameter is determined to exceed the threshold;

comparing the determined exothermic condition with an exothermic condition expected from the catalyst at a time prior to the determined exothermic condition; and

modifying the injected hydrocarbon in accordance with said last-mentioned comparing.

Such is not described in the cited references.

Any questions regarding this matter may be directed to the undersigned. In the event any additional fee is required, please charge such amount to the Patent and Trademark Office Deposit Account No. 50-0845.

Respectfully submitted,

7/31/02

Date

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Attachment: Sheets showing changes made

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COMPARISON OF CHANGES TO SPECIFICATION

Page 4, paragraph 0012:

In one embodiment the common parameter is temperature [/].

COMPARISON OF CHANGES TO CLAIMS

4. (Amended) A method for controlling hydrocarbon injection into an engine exhaust to reduce NOx in such exhaust, such engine exhaust with the NOx and the injected hydrocarbon being directed to a catalyst for reaction therein, comprising:

(a) detecting an exothermic reaction across the catalyst; [and]

(b) detecting a temperature of an output of the catalyst in response to the detected exothermic reaction; and

(c) injecting the hydrocarbon into the reaction in accordance with the detected temperature.

6. (Amended) A method for determining peak efficiency temperature of a catalyst in reducing NOx wherein such NOx is reduced by reacting such NOx in the catalyst with a hydrocarbon, comprising:

(a) detecting a temperature difference across the catalyst;

(b) comparing the temperature difference with a predetermined temperature threshold; and

(c) determining an exothermic condition temperature at an output of the catalyst when the temperature difference is determined to exceed the threshold.